Distribution in brain map and movement of MEG equivalent current dipoles during higher order mental action tasks

I. Kaetsu[1,2], K.Sutani[2], T.Mori[2], K.Uchida[1], M.Tonoike[3], and M.Yamaguchi[3]

[1]*Faculty of Science and Technology, Kinki University*
Kowakae 3-4-1, Higashi-Osaka, Osaka 577-8502, Japan;
[2]*Interdisciplinary Graduate School of Science and Technology, Kinki University*
Kowakae 3-4-1, Higashi-Osaka, Osaka 577-8502, Japan;
[3]*Life Electronics Research Center, Electrotechnical Labovatory,*
Nakakoji 3-11-46, Amagasaki, Hyougo 661-0974, Japan

1 Introduction

MEG is one of the most suitable non-invasive method to study and clarify the higher order mental actions in human. A lots of works has been reported of MEG measurement and analysis on the central region of human senses such as visual, auditory, somatosensory, and olfactory senses and recognitions.

However, research works on the mental actions in eye-closed, silent and unmoved state without sensing have not been studied so widely. For examples, brain actions during various mental tasks such as calculation, word recollection and free imagination are the interesting research targets for MEG measurement and analysis[1,2]. It was expected that MEG would provide some useful informations on the distribution and movement of current dipole over the whole brain regions. It would also show the real time shift of dipole movement during the tasks.

The authors noticed on the difference in the freedom of memory recollection actions between the mental tasks. All tasks has a rule to limit and regulate the memory recollection actions by the purpose of task.

Calculation is regulated by the rule of addition and subtraction to be referred. Word recollections are regulated by the category of words to be reminded and mentioned. Even an imagination is limited also by the range of topic or subject. The permissible range of freedom differs by the strictness of rule and width of subject category. It is an interesting view point to study the effect of such a freedom of memory recollection on the movement of dipoles. In this report, the authors studied by MEG the distribution of assumed current dipoles in the brain cortex space and its time-dependent changes during the performance of various mental tasks with different freedoms for memory recollection actions.

2 Methods

All MEG measurement were carried out using 122ch. whole head type SQUID sensor from Neuromag company which belongs to LERC in Amagasaki, Osaka. Five male healthy persons of 22-65 ages were chosen as the subjects. Four kinds of mental tasks, namely, mental arithmetic, capping, recollection of place name and free imagination on a specific theme were settled. The subject sits in a chair under the SQUID and performed each task for 3 minutes, shutting his eyes.

Graph version2.92 and source Modelling version4.4 from Neuromag were used for the analysis. The original data were filtered, analogue-digital converted and treated by 40 times summation and averaging. A single dipole was assumed and deduced for each 2.5ms interval, based on a trigger signal. Then its shifting changes in space with time was pursued by cutting the dipole of distribution data at any desired interval. The result of dipole analysis was overlapped with MRI imaging picture and investigated.

3 Results

The distribution of dipole track in the cortex was measured and analyzed during the various tasks by 5 subjects.

The shift of dipole position with time was also pursued by analysis. Examples of dipole track distribution in 2 subjects were shown in Figs.1 and 2. Some results of analysis on dipole movement were shown in Figs.3 and 4.

3.1 Mental arithmetic task

According to the results of Figs.1, 2 and 3, the dipole distribution in mental arithmetic task was rather limited in the relatively narrow space range over frontal lobe and temporal lobe and did not dispersed so broad.

3.2 Capping task

Then, the dipole track distribution was analyzed similarly during capping task by the same subjects, as shown in Figs.1 and 2.

It can be said from those results, that the dipole distribution in capping task was plotted in the slightly enlarged space range in comparison to that in mental arithmetic task. But it is still limited in the relatively concentrated space between frontal lobe and temporal lobe.

3.3 Recollection of place names

The same subjects performed the task to recollect any name of known places. The results (Figs. 1 and 2) were analyzed similarly.

It was observed that the dipole distribution during this kind of task is not also dispersed so broad in the cortex space range similarly to the results of capping task.

3.4 Free imagination on a theme

Finally, the tasks of free imagination on a certain specific theme were carried out. Those themes were chosen variously by the subject, including “living being”, “mountain”, “butterfly”, “fish” and “baseball game”.

The typical results of measurement and analysis were included in Figs. 1, 2 and 4.

It is noticed that the dipole distribution in the free imaginations spread remarkably over relatively broad range of cortex space, in comparison to the other mental tasks described in the former sections. The tendency was generally observed in any subject and in any theme of imagination. The reason is discussed in the following section.

4 Discussion

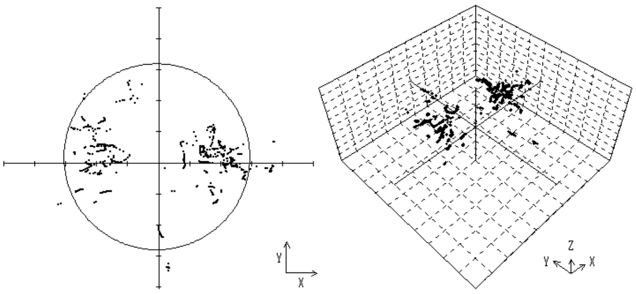
It is supposed that the freedom in memory recollecting actions would increase in the order of mental arithmetic, capping or name task recollection, and free imagination. Capping has the freedom for category of word, but has the regulation for the rhyme of word, while name recollection has the freedom of rhyme, but the regulation of category.

So, which one is more free or restricted task among capping and name recollection, might be different personally. However, the following tendency was generally observed. The track of dipole movement was distributed in a relatively smaller space range in the cortex in the tasks of relatively strong regulation. On the other hand, the dipole distribution was much extended in a relatively broader space range in a more randomly dispersed state in the tasks of relatively large freedom. It is deduced that frontal lobe is the center of recognition and judgment, while temporal lobe concerns to the storage and recollection of memories.

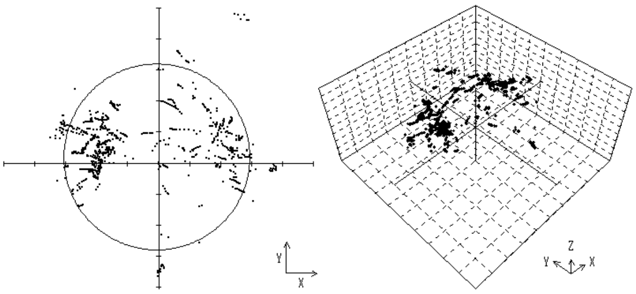
In the mental actions which are regulated strongly by a rule, the main process of mental action might be consisted of memory recollection from temporal lobe and its check in reference to the rule by frontal lobe[3,4]. This might probably be the reason why the dipole tracks were found in a relatively simple and small space between frontal lobe and temporal lobe. But, in the free imagination, memory recollections of much more multiple and complicated kinds might be permitted and those multiple memories would be treated through various centers over whole cortex region. This might probably be the reason why the dipole tracks were found dispersedly in broader range of cortex. More detailed and exact analysis of dipole tracks during the mental actions would be studied in the near future.

References

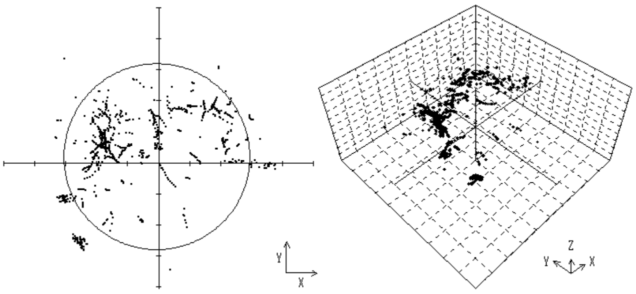
1. I. Kaetsu, K. Uchida, K. Sutani, M. Ioku, M. Hanada, and M. Tonoike, “Memory recollection and electroencephalogram (1); Effect of memory recollection on alpha-wave”, *Rinsyou nouha* **38**, 381-385, 1996.
2. K. Sutani, I. Kaetsu, S. Iwaki, M. Tonoike, and K. Uchida, “Brain activities during word recollection and calculation tasks assessed by MEG measurements”, *J. Japan Biomag. and Bioelectromag. Soc.* **13**, 234-235, 2000.
3. W. Penfield and T. Rasmussen “The cerebral cortex of man : A clinical study of localization of function”: New york : The macmillan Company, 1950.
4. K. Sasaki, T. Tsujimoto, A. Nambu, R. Matsuzaki, and S. Kyuhou, “Dynamic activities of the frontal association cortex in calculating and thinking”, *Neuroscience Resarch* **19**, 229-233, 1994.



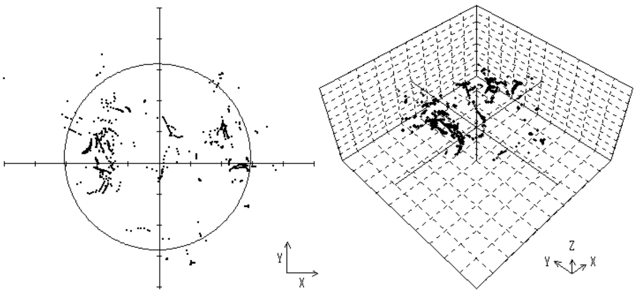
BGt



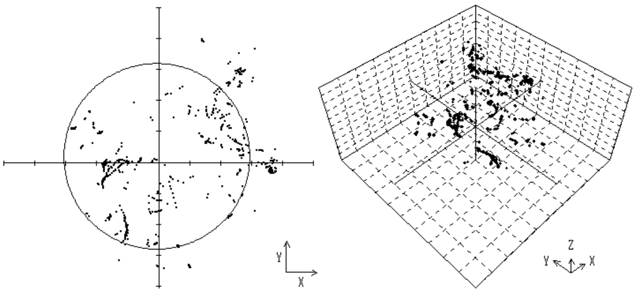
Mental arithmetic



Capping

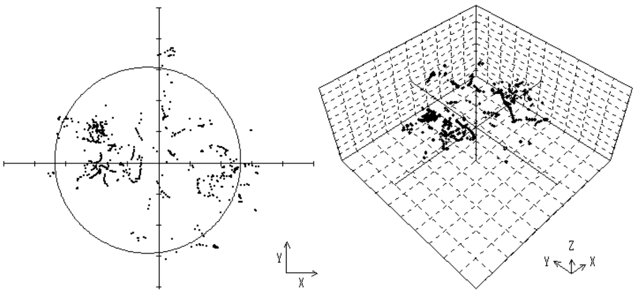


Recollection of place names

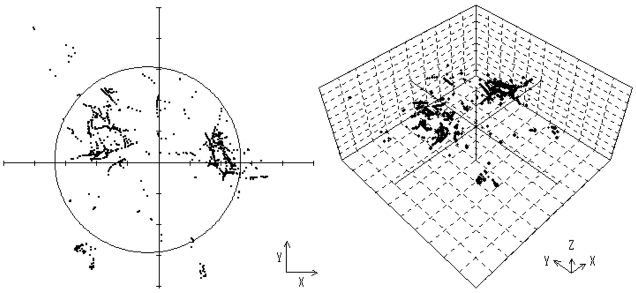


Imagination on living beings

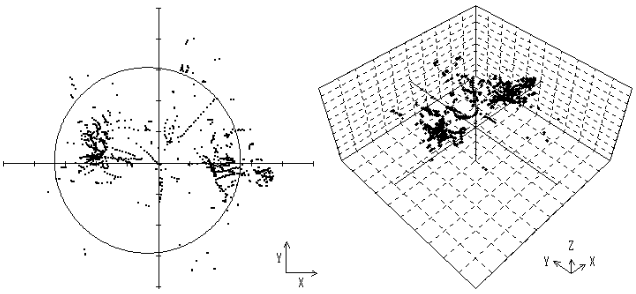
Figure 1: *Dipole distribution during mental tasks by subject Y. Band pass : 4-5Hz, Interval : 2.5ms.*



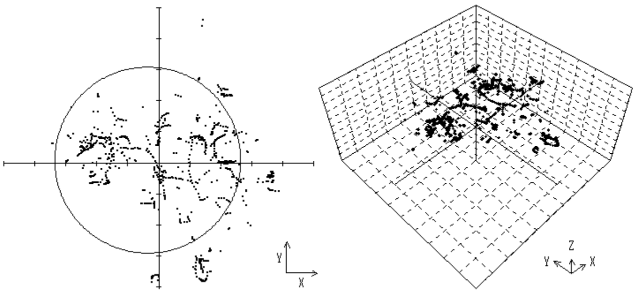
BGt



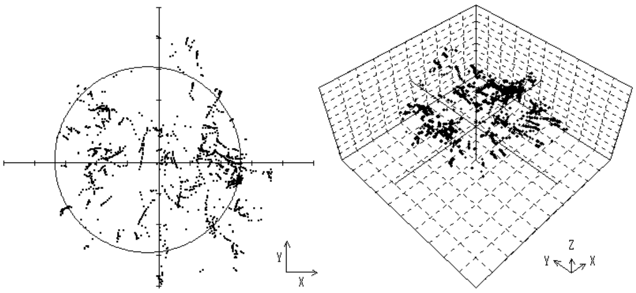
Mental arithmetic



Capping



Recollection of place names



Imagination on living beings

Figure 2: *Dipole distribution during mental tasks by subject H. Band pass: 4-5Hz, Interval: 2.5ms.*

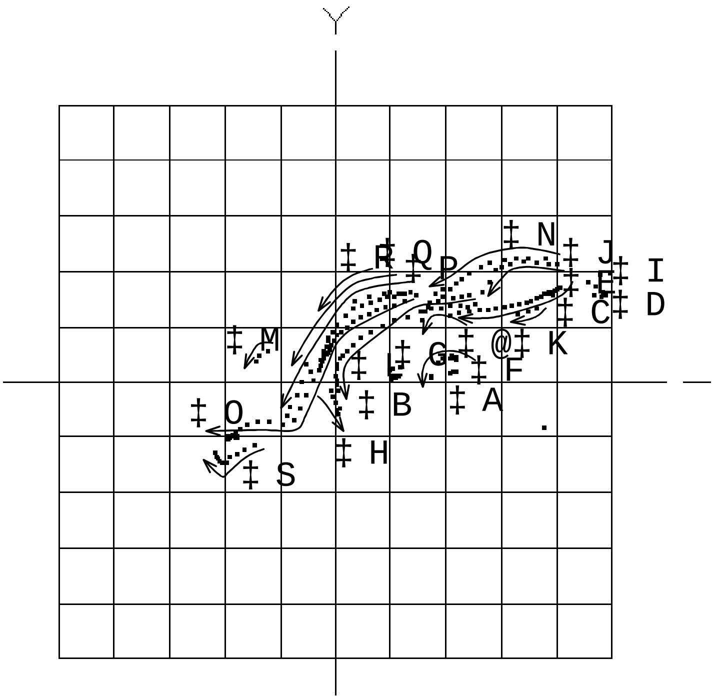


Figure 3: *Tracks of dipole movement during mental arithmetic task by subject K. Band pass: 4-5Hz. Numbers express the order of dipole appearance, arrows express the direction of dipole movement.*

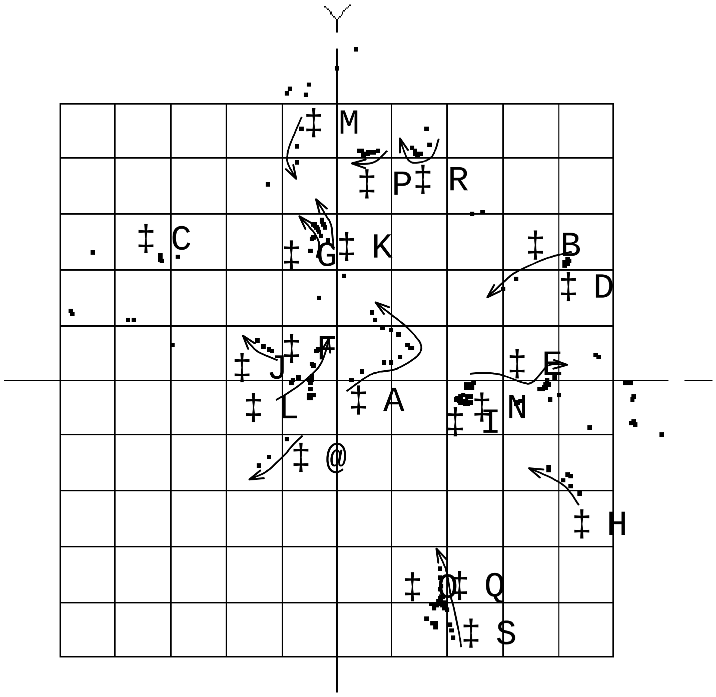


Figure 4: *Tracks of dipole movement during imagination task on "fish" by subject K. Band pass: 4-5Hz. Numbers express the order of dipole appearance, arrows express the direction of dipole movement.*